Chaplin Lake basin

C.2

Saskatchewan
Environment

Hydrology Branch

Chaplin Lake Basin Hydrology Study

SASK. ENVIRONMENT LIBRARY
MAY 7 1982
REGINA

September, 1981
HYD-4-7

SASK. LEGISLATIVE LIBRARY
MAY 7 1982
REGINA

This report has been prepared primarily for internal use by Saskatchewan Government agencies. Material should not be used without approval.

HYD-4-7

CHAPLIN LAKE BASIN

HYDROLOGY STUDY

Prepared by:

H. E. Mahood, P. Eng.
Investigations Division
Hydrology Branch
Saskatchewan Environment

September, 1981

CONTENTS

		Page
	SYNOPSIS	iii
Chapter		
I	INTRODUCTION	1
	A. PHYSICAL ASPECTS AND DEVELOPMENT	1
	B. BACKGROUND TO THE STUDY	5
II	RUNOFF POTENTIAL	8
	A. DRAINAGE AREAS	8
	B. RUNOFF VOLUMES	11
III	LAKE OPERATION WITH AND WITHOUT WATER IMPORTATION	14
	A. PHYSICAL COMPONENTS	14
	B. WATER BALANCE	17
IV	CONCLUSIONS	26

TABLES

1.	DRAINAGE AREAS IN CHAPLIN LAKE BASIN	10
2.	ANNUAL RUNOFF VOLUMES FOR VARIOUS FLOOD FREQUENCIES IN CHAPLIN LAKE BASIN	13
3.	ALLOWABLE WATER IMPORTATION AND FULL SUPPLY LEVELS FOR STUDY CASES IN CHAPLIN LAKE WATER BALANCE	18
4.	EFFECT ON CHAPLIN LAKE WATER BALANCE OF USING DIFFERENT OPTIONS FOR STORAGE OPERATION AND ALLOWABLE WOOD RIVER DIVERSION	21

ILLUSTRATIONS

FIGURE

1. CHAPLIN LAKE SHOWING PRESENT RESERVOIR AREAS AND STORAGE CONTROL WORKS

2. CHAPLIN LAKE BASIN SHOWING DRAINAGE AREAS

3. AREA AND CAPACITY CURVES FOR LAKE STORAGE RESERVOIRS IN CHAPLIN LAKE BASIN

4. LAKE LEVELS UNDER CASE A2 OPERATION - LOCAL RUNOFF ONLY

5. LAKE LEVELS UNDER CASE B4 OPERATION - WATER IMPORTED UP TO GIVEN MAXIMUM

6. LAKE LEVELS UNDER CASE C5 OPERATION - WATER IMPORTED AS REQUIRED

SYNOPSIS

Chaplin Lake, in terms of downstream flow is a closed basin, which does not spill and has no natural outlet. The basin climate, as in other parts of southern Saskatchewan, is semi arid, but is subject to considerable variations. As a result runoff can vary from zero in a particular year to quite high values.

Since 1946 Saskatchewan Minerals has engaged in sodium sulphate retrieval from Chaplin Lake and has carried out certain developments to facilitate its operation. A system of individual storage units with control of flow between units has been developed within the original lake area. Since 1961 a Ducks Unlimited dam on the Wood River has been used to divert water into Chaplin Lake to supplement local runoff.

The present study included estimation of annual runoff to each storage unit from the local drainage area, as well as annual runoff for the basin as a whole.

The study indicated that local runoff in the basin is often insufficient to maintain reservoirs at desired levels. However, this situation can be greatly improved by supplementing local runoff with a limited diversion from Wood River. It was indicated too that if significant diversions from Wood River are to be allowed a lower full supply level on Miller Lake, such as the present summer FSL, would facilitate more economical use of water without depriving the west and east lake reservoirs downstream of their minimum requirements.

Chapter I

INTRODUCTION

A. PHYSICAL ASPECTS AND DEVELOPMENT

Chaplin Lake, located in southern Saskatchewan about half way between the cities of Moose Jaw and Swift Current, existed naturally as a large, saline relatively shallow prairie lake or evaporation basin. The size of the inundated area fluctuated with the general cyclic pattern of wet and dry years and with the effect of inflow and evaporation during each given year.

The extraction of sodium sulphate from Chaplin Lake by Saskatchewan Minerals dates from 1946, with initial construction during that year of brine reservoir #1 near the plant site at Chaplin, with a ditch running out into what is presently known as West Chaplin Lake. From this beginning the operation has continued and expanded. It has long been recognized as an important local industry and one of considerable significance provincially as well.

A basic requirement for the lake operation is a dependable and sufficient supply of water. For example production of the mineral begins with the pumping of the brine into reservoirs during the summer months. As an important consideration, either an excess or shortage of water in the area of concentration is determental to the operation.

In view of the semi arid nature of the climate and the wide variations in local runoff from year to year, it is not surprising that major physical changes have been made in the original Chaplin Lake in order to improve the water supply in years of shortages, and to control

the flow of water between segments of the lake in a way which would facilitate the mineral extraction. As a result of this work "Chaplin Lake" is now divided into four distinct segments or smaller "lakes", as follows: West Chaplin Lake, East Chaplin Lake, Miller Lake and Midtskogan Bay. In this report reference will be made to "Chaplin Lake" as one naturally existing unit including the various components, or to the individual smaller "lakes" as identified above.

On Figure 1 is a map showing the location of these storage units or smaller lakes which are connected by channels, but with gated structures to control the flow. The man made storage of Miller Lake is created by two dams located at the north end of the flooded area. Storage in Midtskogan Bay is increased by means of a dam on the east, and a grid road embankment, which also acts as a dam, on the north-west. This road embankment lies to the south at West Chaplin Lake, but further north along the same road there is a similar embankment separating East from West Chaplin Lake. Water from these various dams or embankments can be released downstream as required, with West Chaplin Lake being the most downstream of the various storage units.

In conjuction with physical changes in the lake area, provision has also been made for the importation of additional water. The Wood River discharges into Old Wives Lake, which at high levels under natural conditions would overflow through Chaplin Creek into Chaplin Lake. Saskatchewan Minerals has over the years required additional water for its sodium sulphate plant at Chaplin, and in conjunction with

Ducks Unlimited has installed works so that water can be diverted directly from the Wood River into Chaplin Creek, regardless of the level of Old Wives Lake. Applications to Water Rights Office for a major allocation for this diversion date back to the 1950's, but an actual water right has never been granted. In practise Saskatchewan Minerals diverts from the Wood River a volume of water which can be quite large but which varies from year to year. An active application is still on file at the Water Rights Office for the right to divert 6000 acre-feet (7400 dam^3) from the Wood River to supplement runoff from the local drainage area.

East Chaplin Lake is a large evaporation basin which when dry has exposed salt areas subject to wind action. Natural runoff into Miller Lake and water diverted from the Wood River can be brought into West Chaplin Lake for the purpose of salt extraction at Chaplin without going through East Chaplin Lake, and by this routing a large additional evaporation loss is avoided. This by-passing of East Chaplin Lake has resulted in problems of blowing salt in years when the local runoff was insufficient to prevent that lake from going dry. Under natural conditions the east lake would not be by passed, but dry conditons could still occur after a succession of low runoff years.

In addition to a high priority demand for water by Saskatchewan Minerals for the sodium sulphate operation, there are other types of use in the Chaplin Lake area.

Agricultural use has been relatively minimal, consisting mainly of small projects scattered through the basin and designed to utilize local runoff. In many cases, this water would not, under natural conditions, contribute to Chaplin Lake inflow but would be stored locally in sloughs or depressions. Overall, any reduction in Chaplin Lake inflow from these developments would tend to be insignificant. In a slightly different context there can be competition for the agricultural use of land in the Miller Lake area. At high levels the lake floods over a large area of grass land that otherwise can be used for pasture or hay production.

A present and potential use for water in the basin, but with a lower priority than for agriculture, is use for wildlife and specifically waterfowl production. Ducks Unlimited (D.U.), as previously noted, has been involved jointly with Saskatchwan Minerals in the Wood River diversion. This joint participation was based on an agreement that some water would be retained in Miller Lake storage for wildlife use. The D.U. dam on the Wood River just downstream from the Chaplin Creek diversion provides channel storage for wildlife purposes, but has the added advantage of creating additional head for the diversion itself.

It should be noted that, unlike East and West Chaplin Lakes, Miller Lake is basically freshwater storage. At normal levels under natural conditions Chaplin Lake would not flood over much, if any, of the area now occupied by Miller Lake. With changes of water and large freshwater inflows occurring annually it is probable that salinity levels in this

lake are quite low compared to those existing downstream in both East and West Chaplin lakes.

B. BACKGROUND TO THE STUDY

Since 1946,when Saskatchewan Minerals first applied for a water right to construct reservoir storage on the north side of Chaplin Lake, there have been many ups and downs in terms of water supply. The situation for sodium sulphate extraction changed from difficulties due to too high runoff in the early 1950's to problems of water shortage starting about 1958. The Wood River diversion came into operation and the Ducks Unlimited dam on the Wood River was completed in 1961. A Water Rights Office hydrology study done in 1962 suggested that the present works were adequate and advised against the creation of additional storage on the Wood River.

The water supply situation and related administrative problems continued to evolve after 1962. In a memo to S. R. Blackwell dated January 12, 1972, the Water Rights Office outlined a number of concerns, including the complaint of Mr. Mackie, a local farmer, of salt blowing from East Chaplin Lake. The memo statee: "The present system of operation is considerably changed from what it was when the last study was completed and may have to change again to accommodate Mr. Mackie. It is possible that a new study may be required in order to sort this matter out." The need for a hydrology study was mentioned also in an internal Water Rights memo dated February 4, 1974, which reported on a meeting with Ducks Unlimited concerning the latter's proposal to develop a wildlife

project in Miller Lake. At this meeting D.U. were advised that a hydrology study would be required before a specific amount of water could be allocated.

In 1972, partially in prepartion for the proposed study, the Hydrology Branch obtained copies of all lake levels and other hydrometric data which had been collected over the years by Saskatchewan Minerals at Chaplin. Gauges were established at each lake on geodetic datum and at the highway bridge on Chaplin Creek near Coderre as part of the provincial hydrometric network. Since 1975 this streamflow station has been operated at the same location by Water Survey of Canada under the name of "Wood River Diversion to Chaplin Lake."

One of the concerns in 1972 which prompted the request for a hydrology study related to the actual availability of additional water which could be diverted to Chaplin Lake from the Wood River. This question was at least partially answered in a hydrology study of the Wood River basin carried out by PFRA Hydrology Division and reported in July, 1974. 1/ The study updated hydrology data in much of the Wood River basin, provided information on the magnitude of Wood River runoff and estimated the effect on Old Wives Lake of diverting water out of the basin.

1/ PFRA Hydrology Report No. 69: "Report on Water Supply for the Proposed Willow Bunch Thermal Power Project," July, 1974.

With the work already done on the Wood River, the present study was directed toward an evaluation of the hydrology of the Chaplin Lake, as separate from the Wood River, basin. This included estimation of local runoff to each of the individual lakes and to Chaplin Creek at the hydrometric station near Coderre. The water balance for each individual lake with different alternatives for operation and full supply levels was investigated, as well as the effect of adding an annual diversion from the Wood River of up to a given maximum amount. in 1978, Saskatchewan Minerals proposed a major change in their use at the lakes, which would have made East Chaplin, rather than Miller Lake, the main storage reservoir. The probable effect of this type of change was investigated by assuming various full supply level combinations for the three storage units, Miller and East Chaplin lakes, and Midtskogan Bay.

Chapter II

RUNOFF POTENTIAL

A. DRAINAGE AREAS

Chaplin Lake is located to the northwest of Old Wives Lake. It has a general elongated shape running from southeast to northwest, with the north western extremity of the original lake bed just south of the Trans Canada Highway and west of Chaplin.

The drainage basin which could contribute runoff to Chaplin Lake, has a similar elongated shape from southeast to northwest, with Chaplin Creek as the only sizable tributary. Along the northeast side, the long common boundary with Moose Jaw River basin is actually the summit of hills in the Missouri Escarpment. This boundary crosses the Trans Canada highway near the urban settlement of Secretan. Relatively high elevations also separate Chaplin Lake from Reed Lake on the west and from Wiwa Creek basin on the southwest. However, there is only a low height of land to the south and southeast, which separates Chaplin Lake from the Wood River and Old Wives Lake respectively. A map of the general area showing various locations in and adjacent to Chaplin Lake basin is shown on Figure 2.

Over most of the basin, apart from the lake area itself, the topography is quite uneven with many depressional areas. On the east side of the basin particularily in the moraine topography of the Missouri Coteau, the surface drainage pattern seems virtually non-existent, with local storage in many sloughs and potholes. From an agricultural standpoint, much of the area is probably pasture land, but with cultivated land located mainly to the south and west of the lake. In terms of relief the highest elevation in the basin is over

400 feet or about 125 metres above the lowest point in West or East Chaplin Lake.

Chaplin Lake, in terms of downstream flow, is a closed basin, which does not spill and has no downstream outlet. For water administration purposes however, it is often considered part of Old Wives Lake basin, of which the principle tributary is the Wood River. The two basins are separated only by a low height of land,as previously mentioned, and are actually connected by an overflow channel, which is the upstream end of Chaplin Creek. Maximum flow levels in the Wood River are such that natural overflow into Chaplin Creek is not expected to occur. On the other hand natural spillage from Old Wives Lake could occur, and probably has occurred in the past. With a series of high runoff years for example, Old Wives Lake could rise considerably above its present normal level. At a certain level Wood River flow near the Chaplin Creek confluence would be submerged, and above a specific higher level the lake would overflow into Chaplin Creek. Such an event would be very unusual and infrequent,however. Old Wives Lake has no other outlet and it is considered that the long term evaporative loss from that lake is equal to the inflow.

Drainage areas were evaluated for Chaplin Lake basin, and for each of the four sub basins tributary to the respective component lakes, using 1:50,000 national topographic maps and aerial photos. The effective, wet and gross drainage area boundaries for the basin and for each of the sub basins were located as shown on Figure 2 and the size of the corresponding drainage areas are listed in Table 1. As

indicated in the tabulation, Miller Lake is the sub basin which has by far the largest local drainage area. It has in fact almost 60% of both the effective and wet drainage area within

TABLE 1

DRAINAGE AREAS IN CHAPLIN LAKE BASIN

Basin or	Sub Basin No.	Effective Drainage Area		Wet Drainage Area		Gross Drainage Area	
		Sq. mi.	Sq. km.	Sq. mi.	Sq. km.	Sq. mi	Sq. km.
West Chaplin Lake	1	66	171	89	231	136	352
East Chaplin Lake	2	41	106	139	360	139	360
Midtskogan Bay	3	9	23	9	23	0	23
Miller Lake	4	166	430	354	917	354	917
Chaplin Creek Hydr. Sta. *	4a	20.3	52.6	20.4	52.8	20.4	52.8
Chaplin Lake	-	282	730	591	153.1	638	1652

* Formerly Chaplin Creek near Coderre, now federally operated as station 5JC005 "Wood River Diversion", located on Chaplin Creek at highway #363 bridge, in NW 9-14-3-W3.

Chaplin Lake basin. Under natural conditions with no dams or embankements to separate the storage all inflow, including that to Miller Lake, would have to contributed to Chaplin Lake as one unit, so there would have been no significance in the sub basin divisions shown on Figure 2 or listed in Table 1.

Although the hydrometric station on Chaplin Creek is presently named "Wood River Diversion", it also has a local drainage area which is part of Miller Lake sub basin. It is this local area which was evaluated and its size listed in Table 1.

B. RUNOFF VOLUMES

Long term hydrometric records in the area near Chaplin Lake are almost non-existent. For the only streamflow station within the basin, on Chaplin Creek near Coderre, there are only a few years of records, and even these consist mainly of measurements, not of natural runoff, but of man made diversion from the Wood River. Considering both the shortness of the record and the origin of most of the measured flow, this station record has little if any value for the purpose of estimating natural inflow to Chaplin Lake.

Wiwa Creek is a tributary of the lower Wood River and, as mentioned previously, its drainage area lies immediately to the west of Chaplin Lake basin. Streamflow in Wiwa Creek has been measured mainly at two locations, but taken together these records cover a relatively short 14 year period. For the former station, Wiwa Creek near Gravelbourg located near the Wood River confluence, records are available for the years 1966 through 1974. The present station is on Wiwa Creek near St. Boswells, located almost two townships upstream from the confluence and for which records are available starting in 1975. Additional to this relatively complete 14 year record of annual runoff, there have been spring runoff and miscellaneous measurements of Wiwa Creek flow in other years. Included among these are partial spring runoff records for 1955 at locations near Hodgeville and Bateman, and for 1965 mainly

near Hodgeville.

After considering other more distant alternatives it was decided, for the purpose of the study, to use Wiwa Creek near St. Boswells as the base station for estimating annual runoff in Chaplin Lake basin. The flow record for the St. Boswells station was extended back to and including 1965 and the additional year 1955, using records of runoff in the basin available for various years as outlined above. Allowance was made for upstream diversions in each of these years to give a set of natural annual runoff volumes for the station during this limited period. A graphical correlation with natural flows for Notukeu Creek near Gravelbourg was then used to extend the period of estimated Wiwa Creek natural flows back to and including the year 1921.

The estimated natural runoff volumes for Wiwa Creek near St. Boswells for the period 1921-78 inclusive were tabulated in order of magnitude. From the plotting position assigned to each value, a frequency curve was drawn on Gumbel probability paper. Runoff volumes for this station were then used to estimate runoff in Chaplin Lake basin and in each of the sub basins on the basis of the relative magnitude of the effective, wet and gross drainage areas. These estimated runoff values were then used, as in the case of Wiwa Creek, to draw frequency curves for the respective drainage areas in Chaplin Creek basin.

In Table 2 are shown the estimated annual runoff volumes for various flood frequencies for each sub basin and for Chaplin Lake basin as a whole.

TABLE 2

ANNUAL RUNOFF VOLUMES FOR VARIOUS FLOOD FREQUENCIES IN

CHAPLIN LAKE BASIN

Drainage Area Identification	Unit	Runoff Magnitude					
		1:2	1:5	1:10	1:15	1:25	1:50
Miller Lake sub basin	ac-ft	2000	7500	12000	15500	20500	27500
	dam^3	2500	9200	15000	19000	25000	34000
Midtskogan Bay sub basin	ac-ft	110	290	430	500	610	750
	dam^3	140	360	530	620	750	950
East Chaplin Lake sub basin	ac-ft	500	2200	4000	5400	7300	10000
	dam^3	620	2700	4900	6700	9000	12000
West Chaplin Lake sub basin	ac-ft	800	2300	3600	4500	6300	8000
	dam^3	1000	2800	4400	5600	7800	9900
Chaplin Lake basin	ac-ft	3400	12000	20000	26000	35000	46000
	dam^3	4200	14800	24700	32000	43000	57000

Chapter III

LAKE OPERATION WITH AND WITHOUT WATER IMPORTATION

A. PHYSICAL COMPONENTS

The works now in place in Chaplin Lake have been developed over the years largely in response to difficulties of both water scarcity and over abundance, particularily as it relates to the Saskatchewan Minerals operation at Chaplin. These works have two basic functions: (1) storage of water, and (2) control of flow. Water can be released our of storage in Miller Lake, for example, to flow into either Midtskogan Bay or East Chaplin Lake, and from each of those storages into West Chaplin Lake.

On Figure 3 are shown curves relating water elevation to flooded area and storage capacity for each of the four Chaplin Lake storage units. Full supply levels for West Chaplin and Miller lakes and Midtskogan Bay shown on Figure 3 are those indicated on project plans filed with Water Rights office, but in addition an optional FSL [1/] for each of Miller and Midtskogan storages, as used in the study, is also shown. The Water Rights plans show no FSL for East Chaplin Lake, but two options used in the study for that lake are also indicated.

Major storage has been developed in Miller Lake by construction of the East and West Mackie dams. Under natural conditions the area presently

---

1/ These optional FSL's were suggested for study by Water Rights Branch, but were chosen with a view to finding which combination of FSL's in the various storages would result in the most economical use of water, and, with other considerations, in the most satisfactory or beneficial storage operation.

occupied by Miller Lake would not start to flood until water depths in the present East and West Chaplin Lakes [1/] exceed about four feet or 1.2 metres, as indicated in Figure 3. Under present development, large volumes of spring inflow, or of water diverted from the Wood River, can be stored in Miller Lake and then released as required. Plans submitted to Water Rights office show a full supply level for this reservoir of 2176.0 feet (663.245 metres), which is much higher than any normal or expected levels (even under natural conditions) in the present East or West Chaplin Lakes.

The previously mentioned alternative FSL for Miller Lake was assumed for study purposes at 2173.5 feet (662.48 metres). This alternative would satisfy the agreement with D.U. to keep some water in Miller Lake for wildlife and yet would permit use of much of the area, flooded at the higher FSL, to be used for grazing purposes. It would also fit into the major change, proposed by Saskatchewan Minerals in 1978, to make East Chaplin rather than Miller Lake their main storage reservoir. Some temporary flooding in the spring above this lower FSL can be expected, but this could even be beneficial to grass or hay production as long as the period of flooding is sufficiently limited.

Midtskogan Bay is a smaller developed storage with the same FSL shown on the plans as for Miller Lake, but with a dry elevation close to that of East and West Chaplin lakes. Midtskogan Bay compares favourably

---

1/ In the absence of detailed topography in the main area of East and West Chaplin lakes, the dry elevation in both lakes was assumed to be 2167.4 feet (660.624 metres). This is the lowest lake bed elevation shown on a profile of North Grade "D", which is the constructed embankment separating the two lakes.

in storage efficiency to Miller Lake since, for example, at their common FSL shown on Figure 3 Midtskogan Bay has almost one half the storage capacity but only one sixth the flooded area of Miller Lake. The location of Midtskogan Bay also contributes to its value within the present water control system. Water can be stored efficiently in this reservoir and then released directly as required to West Chaplin Lake, or, less frequently perhaps, through another control structure and ditch into East Chaplin Lake. For Midtskogan Bay, as for Miller Lake, the previously mentioned alternative FSL for the study was 2173.5 feet (662.48 metres). This lower FSL on one or both of these lakes would mean that less water is required to bring them to FSL, and it was felt that the possibility of an overall saving of water requirement should be investigated.

West Chaplin Lake is the area of main operation in sodium sulphate retrieval. For the purpose of brine concentration it is advantageous to severely limit use of the lake for storage, and to supply only the amount of water immediately required to facilitate the operation. Water Right plans show a very low FSL for this lake of 2168.11 feet (660.840 metres) which is less than one foot above the assumed dry elevation of the lake. Dykes have been constructed across the flat bed of the lake, probably for reasons of better water control and efficiency, such as a reduction in the storage area and limitation of water movement under wind conditions. For example a relatively small area of the flat lakebed can be flooded to the desired water level, and the upsetting effect of wind on this level would be greatly

reduced. At FSL, with no dykes and no wind, almost half of the area in the west lake within the old lakebed would be flooded at very shallow depth. This characteristically flat lakebed of West Chaplin Lake is indicated in the appropriate area curve shown on Figure 3.

Although East Chaplin Lake has about the same dry elevation as the west lake, it has, in comparison, only a small area of flat lakebed. In fact, the topography of the east lake is such that its potential storage efficiency compares favourably to that of Miller Lake. For example, for an East Chaplin Lake storage volume equal to that at present FSL in Miller Lake, shown in Figure 3, the flooded area in East Chaplin Lake is only about three quarters of that in Miller Lake. This difference in surface area for the same volume varies considerably, and at some other magnitudes of equivalent storage the comparison for storage efficiency is less favourable to East Chaplin Lake.

Apart from its potential use for storage, and as previously mentioned, problems have arisen in the past from allowing the east lake to go dry. Blowing salt from a dry lakebed can be quite damaging to adjacent agricultural and pasture land.

B. WATER BALANCE

The present storage and control works alone have probably improved the water supply situation for Saskatchewan Minerals in Chaplin Lake. In addition to this the local water supply is augmented in most years by sizeable diversion from the Wood River.

In the water balance study various alternatives for water management and the operation of works were investigated. There are several important considerations in this regard, that can be identified as follows: (1) the top priority of having a reliable supply of water so that West Chaplin Lake, with its present small storage capacity, can be brought up to FSL every year, (2) the importance of avoiding a frequently dry lakebed in East Chaplin Lake, with the associated problem of wind blown salt, and (3) as a lower priority, some consideration for maintaining limited freshwater storage, for purposes such as wildlife, in Miller Lake during the summer months. Affecting all other considerations is the need for effective and economical use of water, which is increasingly regarded as a scarce and valuable resource.

It was necessary to consider the water balance in Chaplin Lake with the present works in place. The water balance study was carried out under each of three main categories concerning water importation to supplement local runoff. Under category "A" no additional water was imported, and only local basin runoff could be used. Category "B" allowed diversion from the Wood River of up to 6000 acre-feet (7400 dam^3) 1/ as required, in any one year.

Under category "C" it was assumed that water could be diverted from the Wood River in any amount required to bring the lakes up to the respective designated FSL each spring. In the water balance calculations,

---

1/ This volume was chosen because, as previously mentioned, Saskatchewan Minerals has applied for the right to divert this amount in any one year from the Wood River.

shortages could arise under categories A and B, and in such an event, first priority for the available water went to West Chaplin Lake for the sodium sulphate operation.

TABLE 3

ALLOWABLE WATER IMPORTATION AND FULL SUPPLY LEVELS FOR STUDY CASES IN CHAPLIN LAKE WATER BALANCE

Study Category	Wood River Diversion Allowed	Study Case	Unit of Measure-ment	FULL SUPPLY LEVEL			
				Miller Lake	Midtskogan Bay	East Chaplin Lake	West Chaplin Lake
A	0	A1	feet	--	2176.0	2173.5	2168.11
			metres	--	663.24	662.48	660.84
		A2	feet	2173.5	2176.0	2172.0	2168.11
			metres	662.48	663.24	662.03	660.84
B	Up to 6000 ac-ft or 7400 dam^3	B1 & B2	feet	2176.0	2176.0	2172.0	2168.11
			metres	663.24	663.24	662.03	660.84
		B3	feet	2173.5	2173.5	2173.5	2168.11
			metres	662.48	662.48	662.48	660.84
		B4	feet	2173.5	2173.5	2172.0	2168.11
			metres	662.48	662.48	662.03	660.84
		B5	feet	2173.5	2176.0	2173.5	2168.11
			metres	662.48	663.24	662.48	660.84
C	Any amount to bring Chaplin Lake storage to FSL	C1	feet	2176.0	2176.0	2173.5	2168.11
			metres	663.24	663.24	662.48	660.84
		C2	feet	2176.0	2176.0	--	2168.11
			metres	663.24	663.24	--	660.84
		C3	feet	2173.5	2176.0	2173.5	2168.11
			metres	662.48	663.24	662.48	660.84
		C4	feet	2173.5	2176.0	2172.0	2168.71
			metres	662.48	663.24	662.03	660.84
		C5	feet	2173.5	2173.5	2172.0	2168.11
			metres	662.48	662.48	662.03	660.84

Table 3 identifies the study cases within each category for which water balance calculations were carried out, with the corresponding FSL assumed for each lake or storage unit.

Under category A, using local runoff only, an equalization by gravity was assumed between Miller Lake and Midtskogan Bay by the end of spring runoff. This allowed Midtskogan Bay, as the main storage for supplying West Chaplin Lake, to be brought up to, or as near as as possible to, FSL with no pumping. Next, water in Miller Lake in excess of FSL or of summer level was spilled into East Chaplin Lake in order to bring that lake up as close to a desirable level as the available water supply would allow. In study case A1 no FSL was set for Miller Lake and so that lake was taken down to a dry level 1/ in many years in order to supply East Chaplin Lake.

Under category B also, in the event of shortages, Miller Lake level was equalized with Midtskogan Bay, before allowing spillage by gravity into East Chaplin Lake. The difference in the various study cases under each of categories A, B and C is mainly the difference in combinations of storage FSL set for each particular case and these are listed in Table 3. One exception is that study cases B1 and B2 have exactly the same combination of FSL's and so the difference between these two cases lies elsewhere. For B1 it was assumed that, in the event of a shortage, East Chaplin Lake would have some priority over Miller Lake for the available water, to the

---

1/ In practise this would mean pumping to reduce Miller Lake to a dry level, since with the present outlet control structures there would be no gravity outflow from Miller Lake below an elevation of 2173.0 feet or 662.33 metres.

extent that up to 2000 acre-feet (2470 dam^3) would be transferred to East Chaplin Lake to bring that lake up to, or closer to, FSL. In case B2, under shortage, the priority for the available water went to Miller Lake with the east lake getting only spillage from Miller Lake which was above that lake's FSL.

For study case C2 no FSL for East Chaplin Lake was listed in Table 3 since that lake was essentially bypassed or excluded from the storage system. In this operation only enough water was imported from the Wood River to bring the other three storage units up to their respective FSL's. The only consistent inflow to East Chaplin Lake was local runoff from that tributary sub basin, with occasional spillage from Miller Lake under high runoff conditions.

Table 4 summarizes the effect on the water balance of using different combinations of full supply level and rules of storage operation, and of varying the allowable quantity of imported water.

The percentage of years that West Chaplin Lake reached FSL and East Chaplin Lake reached 2172.0 feet (662.03 metres) is listed Table 4. It is important for the west lake, with its small storage and priority for mineral extraction, to be brought to FSL in 100% of the years. For the east lake, at the above mentioned level, a sufficiently large area of the lake bed would be flooded to prevent a serious salt blowing problem in that lake. Even if the east lake does not always reach the designated level, it may not drop to an entirely dry level after seasonal evaporation. The percent of years during the study period that dry conditions occurred in the east lake is also indicated.

TABLE 4

EFFECT ON CHAPLIN LAKE WATER BALANCE OF USING DIFFERENT OPTIONS FOR STORAGE OPERATION AND ALLOWABLE WOOD RIVER DIVERSION

Study Case	Wood River Diversion				Percent Years Lake Reached Given Level		East Chaplin Lake		
	Average over 58 Yr. Period		Maximum in any year				Ave. Max. W. L.		(After Evap) % Yrs. Lake Dry
	ac-ft	dam^3	ac-ft	dam^3	West Lake FSL*	East Lake 2172.0 ft (662.03 m	feet	metres	
A1	0	0	0	0	72	41	2171.3	661.81	16
A2	0	0	0	0	79	36	2170.6	661.60	36
B1	4896	6039	6000	7400	100	26	2171.2	661.78	0
B2	4900	6045	6000	7400	100	26	2170.4	661.54	36
B3	4336	5348	6000	7400	100	69	2172.8	662.27	0
B4	3280	4046	6000	7400	100	66	2172.3	662.12	0
B5	4590	5662	6000	7400	100	72	2172.6	662.21	0
C1	10847	12936	23260	28690	100	100	2173.5	662.48	0
C2	5513	6800	12490	15410	100	19	2170.0	661.42	40
C3	6508	8027	16560	20430	100	100	2173.5	772.48	0
C4	4313	5320	12070	13890	100	100	2172.7	662.25	0
C5	3778	4651	9470	11680	100	100	2172.7	662.25	0

* West Chaplin Lake FSL is 2168.11 feet (660.84 metres).

As shown in Table 4 West Chaplin Lake was brought up to FSL in 100% of the years within the study period under categories B and C, in which the local water supply was supplemented by diversion from the Wood River. Under Category A,with only local runoff available, the west lake was brought up to FSL in 79% of the years with study case A2, and in 72% with A1. The average shortage, for those years in which a shortage occurred, is not listed in Table 4 but is calculated at 897 acre-feet (1106 dam^3) for A1 and 661 acre-feet (815 dam^3) for A2. On the other hand East Chaplin Lake was dry in only 16% of the years in study case A1, compared to 36% in A2.

If one of the requirements in operating the system is to keep East Chaplin Lake from going dry, then study cases B2 and C2 can be discarded as unsatisfactory. In C2 the east lake was virtually excluded and in B2 it was given no priority for the abailable water, with the result that dry conditions occurred in 40% of the years in C2 and 36% in B2. Despite this, the average diversion for B2 was quite high compared to that for other study cases in the B category.

For categories B and C a lower FSL in Miller Lake, such as 2173.5 feet (662.48 metres), can significantly reduce the diversion requirement without causing shortages in the west lake or lowering the average water level in the east lake. This is shown in Table 4 by comparing the average diversion required for case C1 to that required for C3. A further reduction in diversion requirement is also possible by setting the FSL for Midtskogan Bay at the same low level as that mentioned for Miller Lake. This is illustrated in a significantly lower average diversion required in case C5 compared to C4 and in case B3 compared

to B5. The FSL set for East Chaplin Lake also has an effect on the diversion requirement. For example,the only difference in conditions controlling cases B3 and B4 lies in the FSL set for East Chaplin Lake. In case B4, with the lower FSL set for that lake the average diversion requirement is about 24% less than for B3.

For wildlife purposes, Miller Lake is required to reach a summer FSL of 2173.5 feet (662.48 metres). Although not listed in Table 4, this level was reached in 100% of the years for all study cases in B and C categories, and it was reached in 45% of the years in study case A2. In A1, since no priority was given to this requirement, the summer level was reached in only 20% of the years and the lake was entirely dry after spillage in about three quarters of the study period.

In Table 4, the diversion quantities shown, especially for the maximum in any one year, are much larger for study cases in category C than for comparable storage operations in category B. While it was assumed for study purposes in category C that any quantity of water required for Chaplin Lake storage would be available, this, in actual fact, may not always be the case. The maximum diversion will likely be needed in a low runoff year or after a series of such years. There is even a probability that years of large or maximum shortage in Chaplin Lakes will coincide with years of low runoff in the Wood River, so the water supply actually available for diversion in these years may be limited, either now or in the future with increasing basin use.

Within category B, study cases B3, B4 and B5 are shown in Table 4

to require, on the average, significantly smaller diversions and yet maintain East Chaplin Lake at consistently higher levels than do study cases B1 and B2. On the basis of these results B3, B4 and B5 appear preferable to the other options studied. Of these preferred options, B4 has a lower average diversion but the average maximum level in the east lake is about half a foot lower than for B3. A choice between B3 and B4, the two options with the lowest average diversion, may be a choice mainly of how high East Chaplin Lake should be maintained.

Water levels for one study case in each of the three categories A, B, and C, were plotted and are shown on Figures 4, 5 and 6. Water levels for each storage unit over the 58 year study period 1921-78 inclusive are shown for study case A2 in Figure 4, B4 on Figure 5 and C5 on Figure 6. For study case A2, with only Chaplin Lake basin runoff available, Figure 4 tends to show the cyclic pattern of local runoff, including extremes of shortage in the early 1930's and of excess supply in the 1950's.

For study case B4 as plotted on Figure 5 there is a large improvement in supply for those years for which a shortage was indicated in Figure 4. Further improvement is indicated in case C5, as plotted on Figure 6, with Miller and East Chaplin lakes shown as reaching their respective FSL's in 100% of the years. Both West Chaplin Lake and Midtskogan Bay reached their respective FSL's in every year during the period in both study cases B4 and C5. However, in the case of Midtskogan Bay this is not shown because the high spring levels plotted for that storage

in Figures 4, 5 and 6 represent the water level after draft, that is, the level after the required release to West Chaplin Lake has been made.

Chapter IV

CONCLUSIONS

From the results of this study the following conclusions can be drawn:

1. Over an extended period of years the water supply provided by local runoff alone is often insufficient to maintain the present Chaplin Lake storage units at acceptable levels. Therefore to realize this objective, some importation of water from the Wood River is required.

2. Midtskogan Bay has a smaller surface area for a give storage volume, up to its present FSL of 2176.0 feet (663.24 metres), than either Miller or East Chaplin Lake. Therefore, in a situation where no diversion from the Wood River is allowed, maximum use should be made of this storage for supplying West Chaplin Lake. This can be enhanced by maintaining some level of storage in Miller Lake, such as adopting an FSL for Miller Lake at least equal to the present summer FSL, and specifying a lower FSL for East Chaplin Lake to minimize demands there.

3. A policy of allowing an annual diversion of up to 6000 acre-feet (7400 dam^3) into Chaplin Lake,as required, should result in a large improvement over no importation in bringing the storage units to a desirable level each year. Such a level of importation could bring West Chaplin Lake to its present FSL and Miller Lake to its summer FSL every year and supply enough water to East Chaplin Lake to keep it from going dry in any year.

4. If water is imported to the basin in any amount required to bring Chaplin Lake storage units up to their respective FSL's, then the volumes imported for a given storage operation would be larger, both

in the average over the study period and in the maximum in any one year, as compared to having a 6000 acre-foot (7400 dam^3) maximum allowable importation. This is illustrated by a 16% increase in the average diversion in study case C5 compared to B4. In these two study cases the only difference in storage operation was in the allowable diversion.

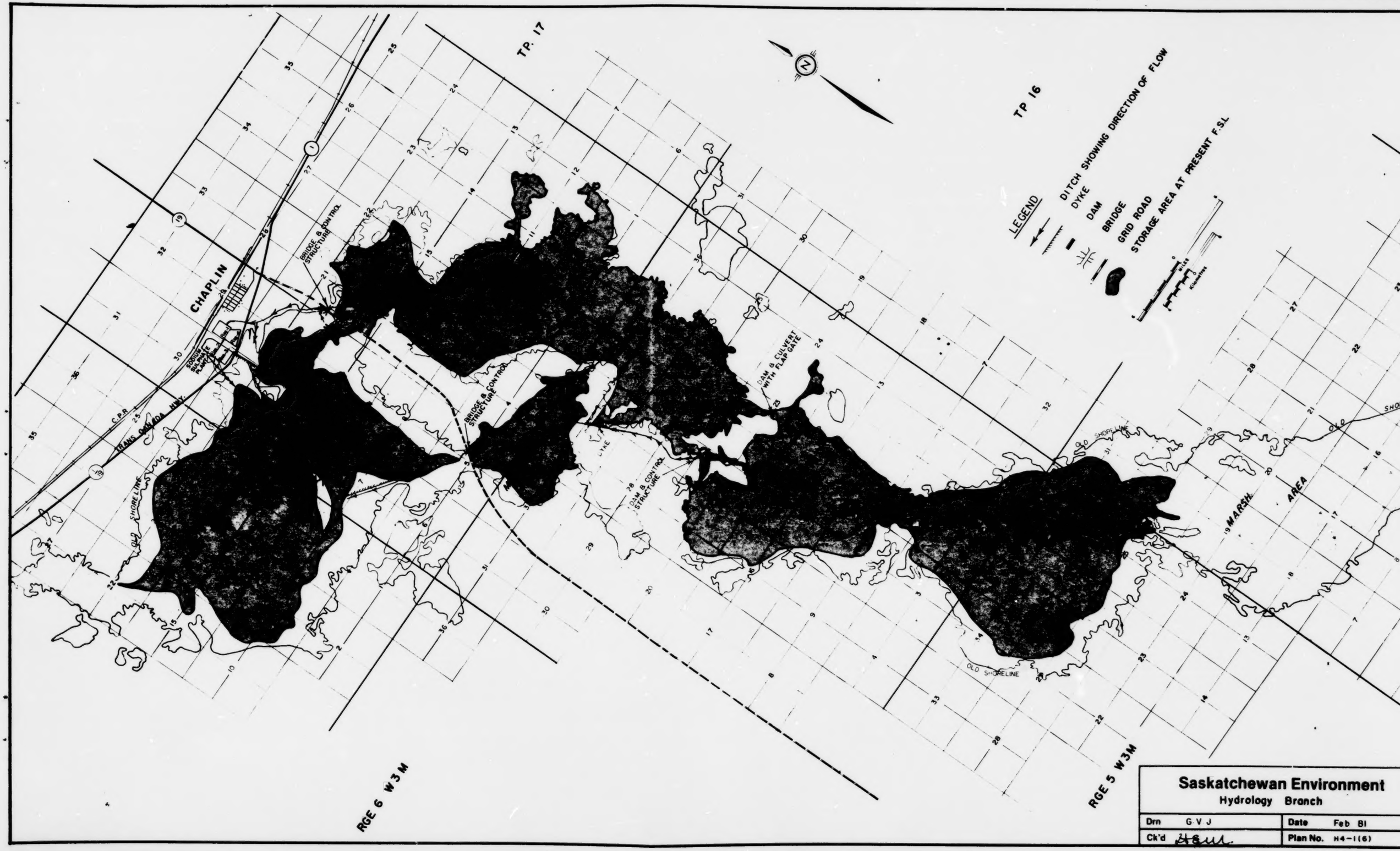
5. It is not necessary to maintain an FSL for Miller Lake of 2176.0 feet (663.24 metres), as shown on the Water Rights plans, to best supply the needs of the two lower lying east and west lakes. Assuming that the minimum requirements for the system are that each year Miller Lake be up to its summer FSL of 2173.5 feet (662.48 metres) after spillage, that West Chaplin Lake reach its FSL, and that enough water be supplied to East Chaplin Lake to keep that lake from going dry, these minimum requirements can be met with much smaller volumes of imported water if the FSL for Miller Lake is set equal to the above mentioned summer FSL.

6. Given the minimum requirements outlined in point 5 above, and Miller Lake FSL set at the summer FSL as suggested, a further reduction in the volume of imported water can be effected if the FSL for Midtskogan Bay is reduced from 2176.0 feet (663.24 metres) shown on Water Rights plans to 2173.5 feet (662.48 metres), the same as for Miller Lake.

   In the water balance study with Wood River diversion permitted, no shortages in the supply for West Chaplin Lake occurred during the study period using the lower FSL for Midtskogan Bay.

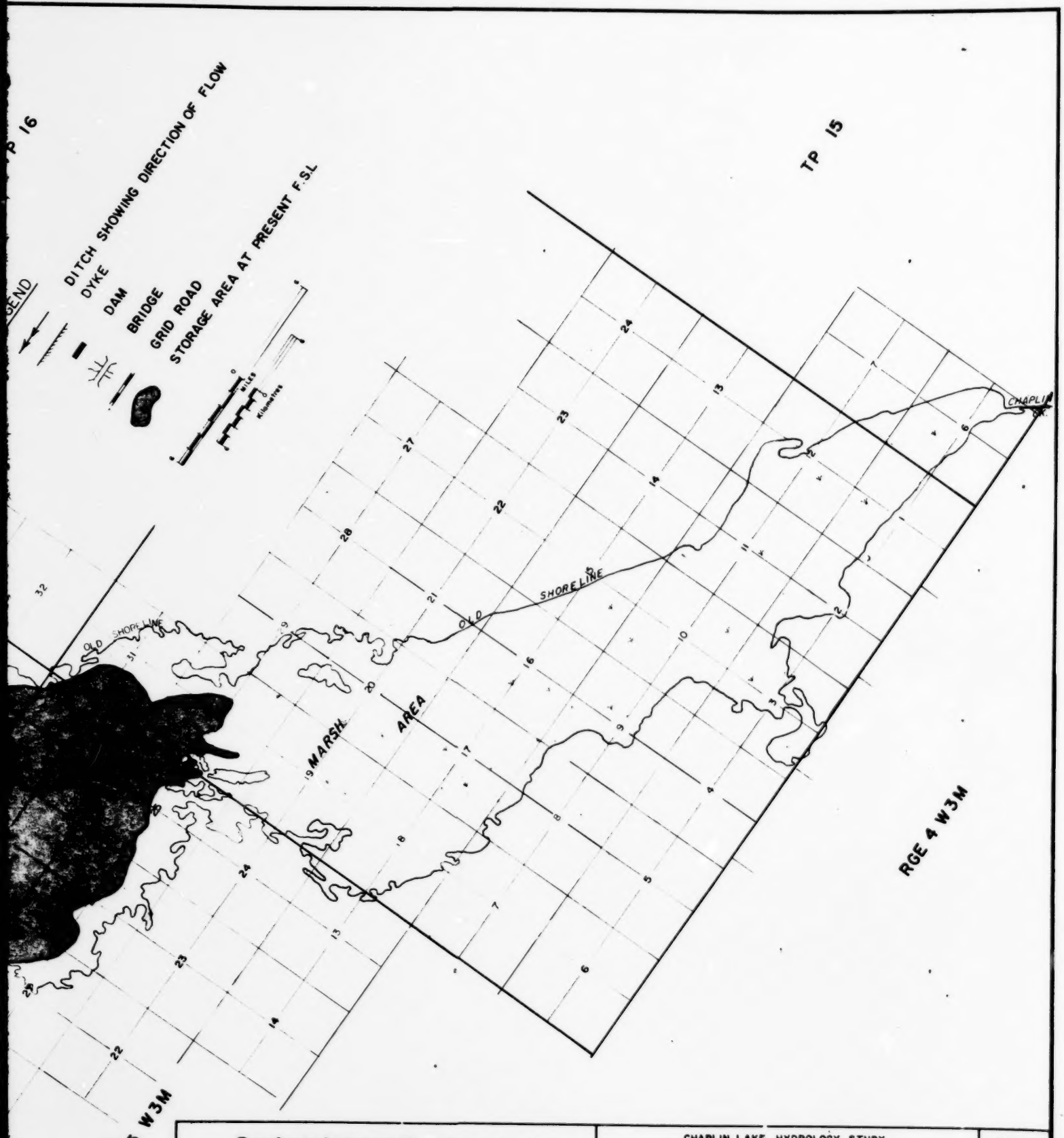
7. Given the lower FSL's for Miller Lake and Midtskogan Bay, as outlined in points 5 and 6 above, choices can still be made concerning the level at which it is desired to maintain East Chaplin Lake. The results of applying two optional levels for the east lake FSL in the study indicates that a higher, as compared to a lower, FSL in that lake will require a larger average Wood River diversion.

8. With a 6000 acre-foot (7400 dam^3) limitation on annual diversion, East Chaplin Lake will not necessarily reach its designated FSL in every year. Depending on the storage operation selected however, the average maximum water level in the east lake can be close to, and in one study case (B4) actually exceeded, the given FSL for that lake.

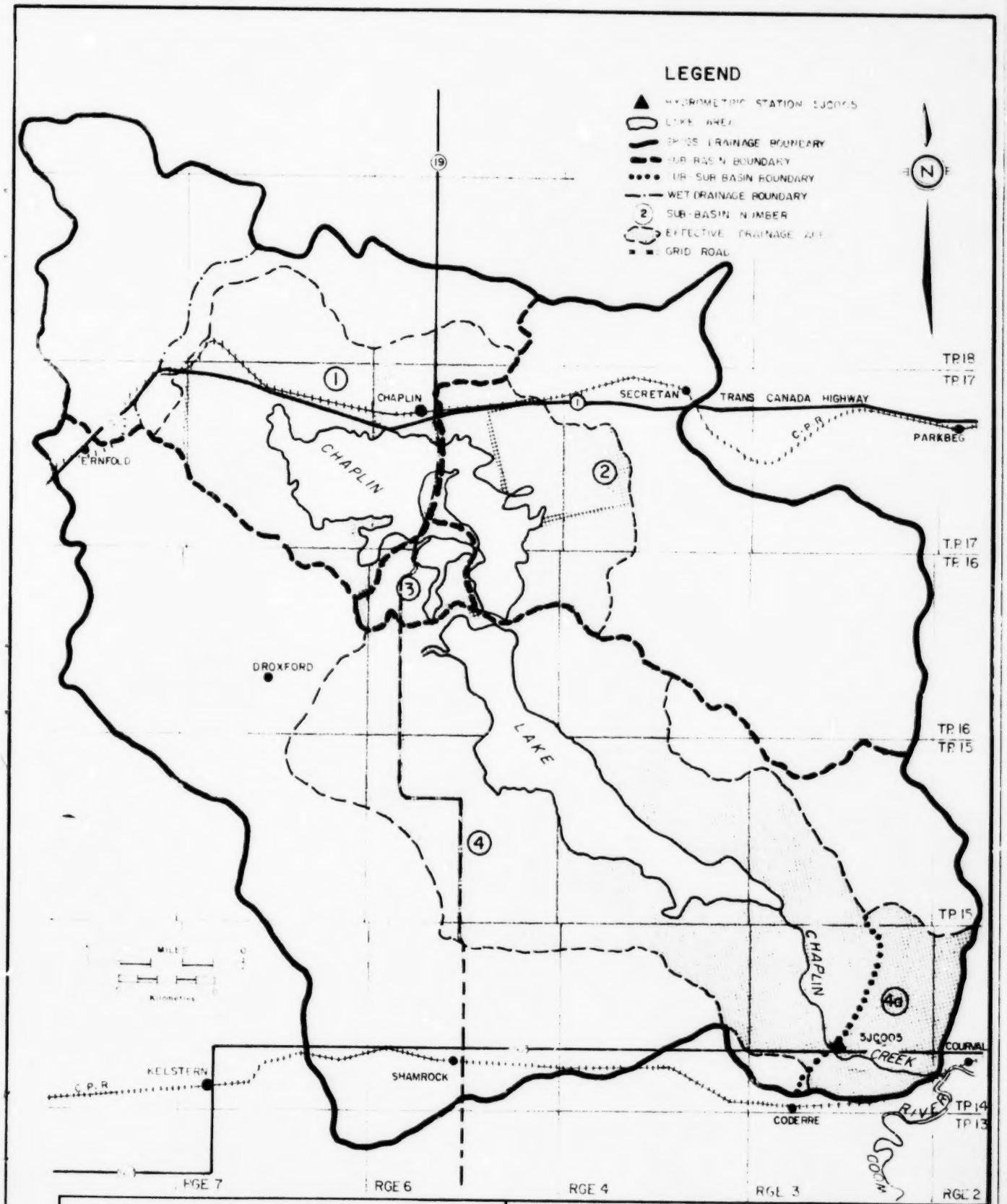


Saskatchewan Environment
Hydrology Branch

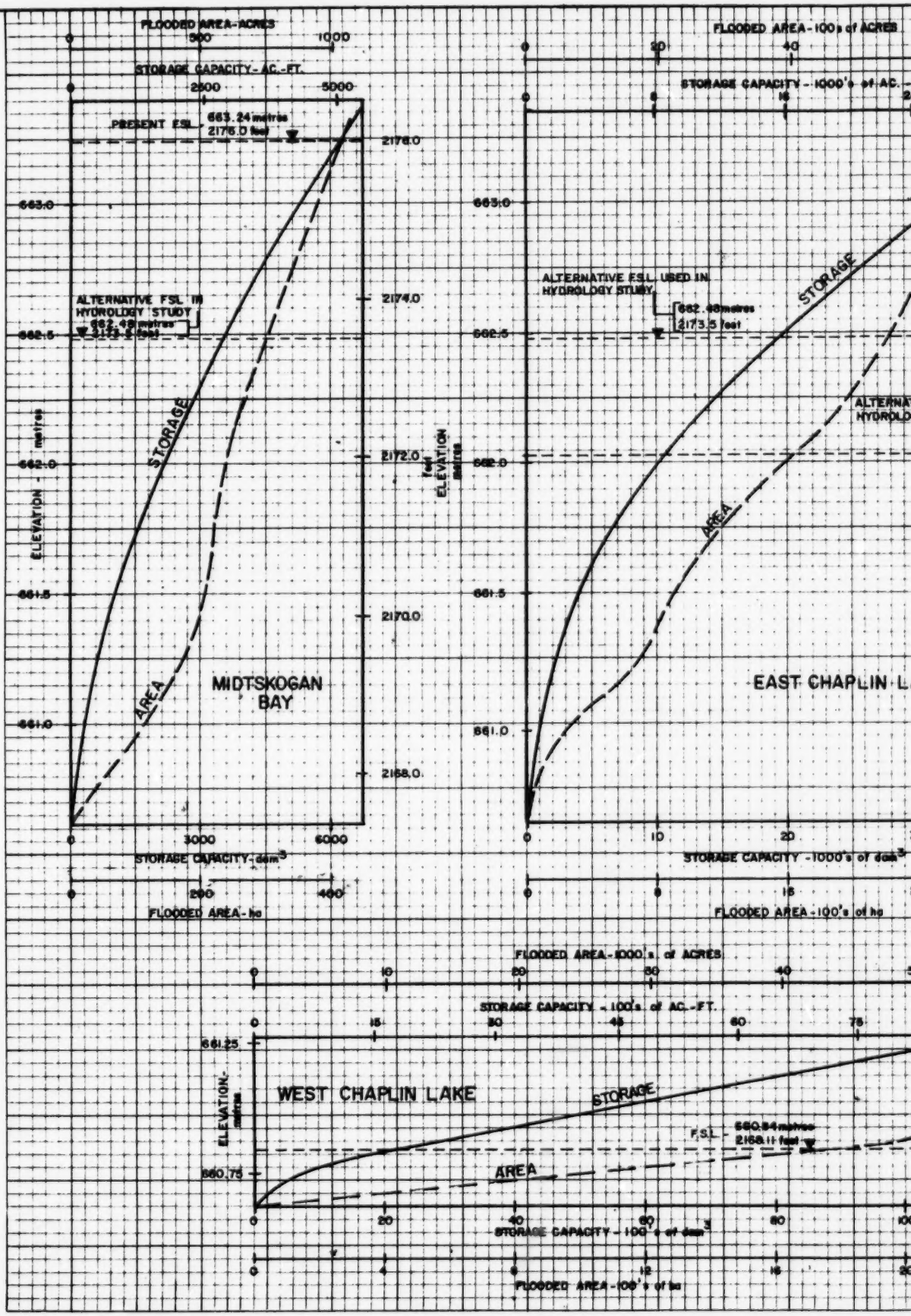
Drn G V J	Date Feb 81
Ck'd	Plan No. H4-1(6)

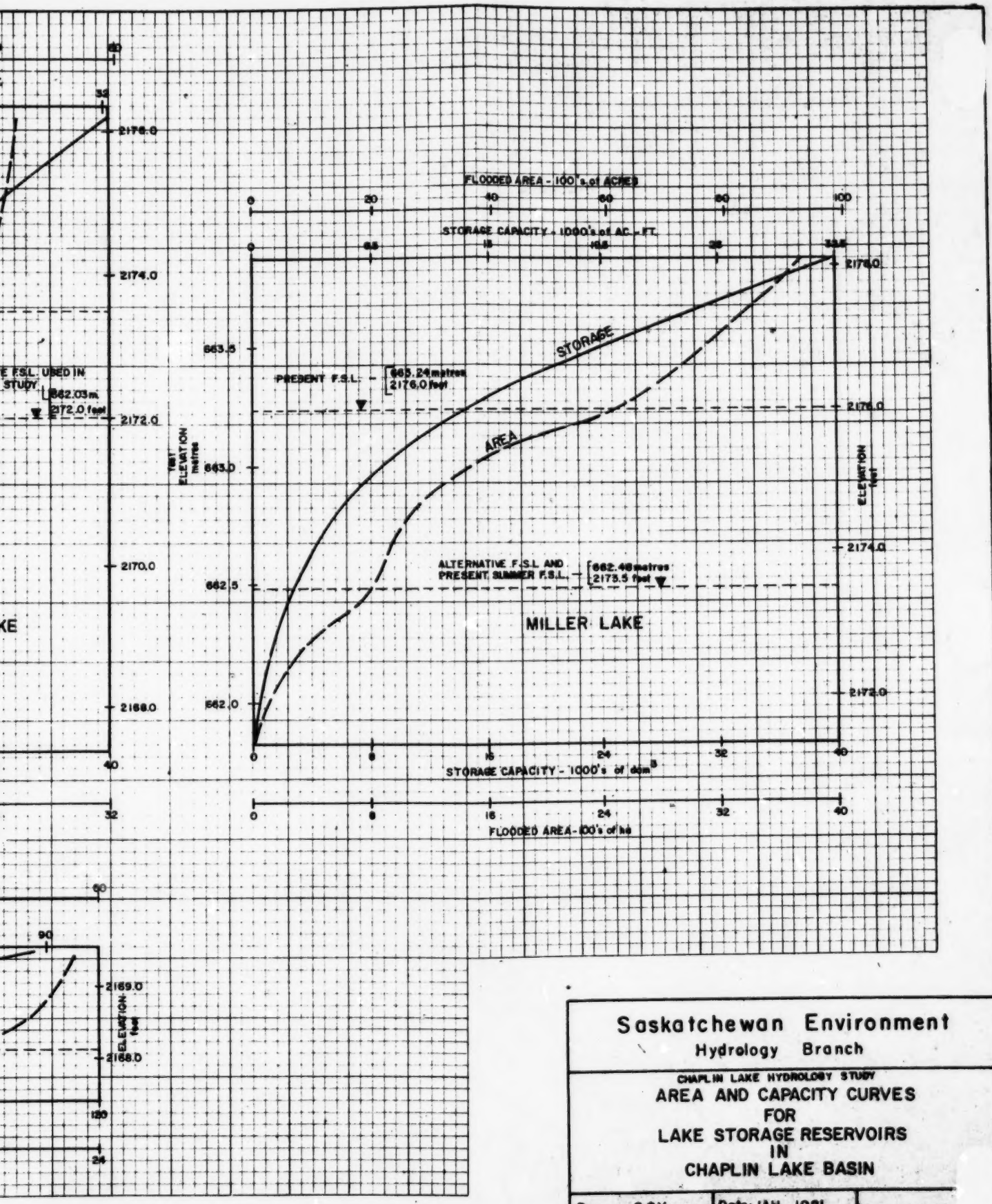


Saskatchewan Environment Hydrology Branch		CHAPLIN LAKE HYDROLOGY STUDY CHAPLIN LAKE SHOWING PRESENT RESERVOIR AREAS AND STORAGE CONTROL WORKS	Figure
Drn G.V.J	Date Feb 81		1
Ck'd H.G.M.	Plan No. H4-1(6)		



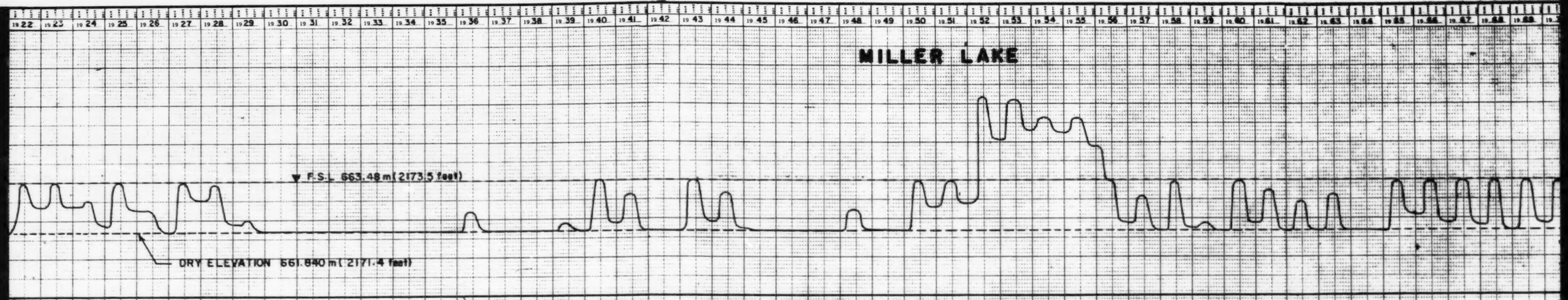
Saskatchewan Environment Hydrology Branch		CHAPLIN LAKE HYDROLOGY STUDY CHAPLIN LAKE BASIN SHOWING DRAINAGE AREAS	Figure 2
Drn J.B	Date JAN./81		
Ck'd H.E.M.	Plan No. H4-1(7)		


FLOODED AREA - ACRES
STORAGE CAPACITY - AC. - FT.
PRESENT FSL 663.24 metres 2176.0 feet
ALTERNATIVE FSL IN HYDROLOGY STUDY 662.48 metres 2173.5 feet
ELEVATION - metres
feet ELEVATION metres
STORAGE
AREA
MIDTSKOGAN BAY
STORAGE CAPACITY - dam³
FLOODED AREA - ha
FLOODED AREA - 100's of ACRES
STORAGE CAPACITY - 1000's of AC. -
ALTERNATIVE FSL USED IN HYDROLOGY STUDY
662.48 metres 2173.5 feet
EAST CHAPLIN L
STORAGE CAPACITY - 1000's of dam³
FLOODED AREA - 100's of ha
FLOODED AREA - 1000's of ACRES
STORAGE CAPACITY - 100's of AC. - FT.
WEST CHAPLIN LAKE
F.S.L. 660.84 metres 2168.11 feet
STORAGE CAPACITY - 100's of dam³
FLOODED AREA - 100's of ha

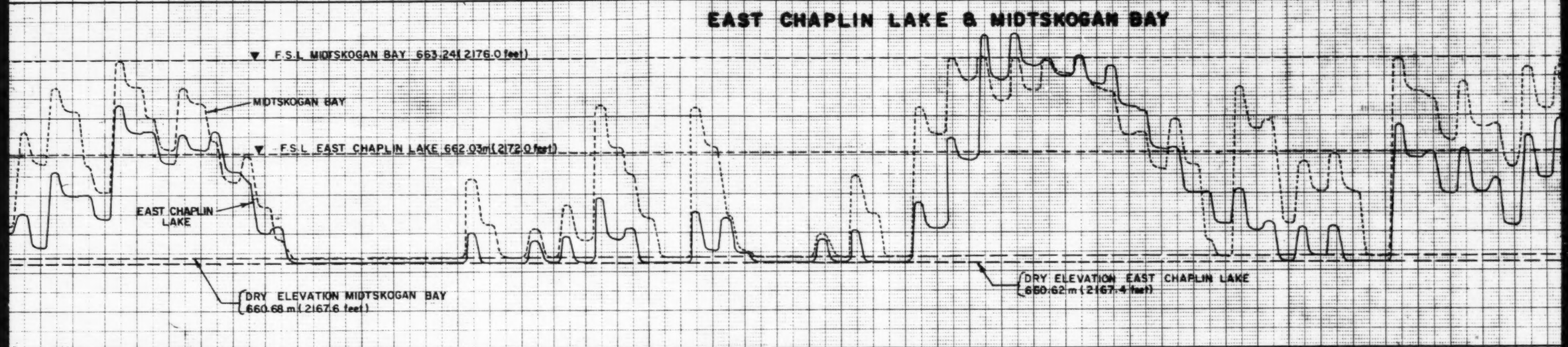


Saskatchewan Environment Hydrology Branch		
CHAPLIN LAKE HYDROLOGY STUDY AREA AND CAPACITY CURVES FOR LAKE STORAGE RESERVOIRS IN CHAPLIN LAKE BASIN		
Drn. G.S.Y.	Date: JAN., 1981	Figure 3.
Ckd. [illegible]	Plan No. H4-1(8)	

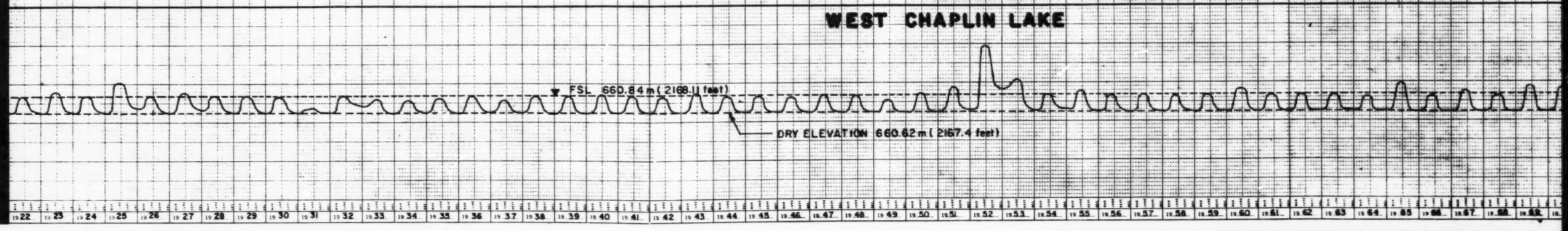
MILLER LAKE



EAST CHAPLIN LAKE & MIDTSKOGAN BAY

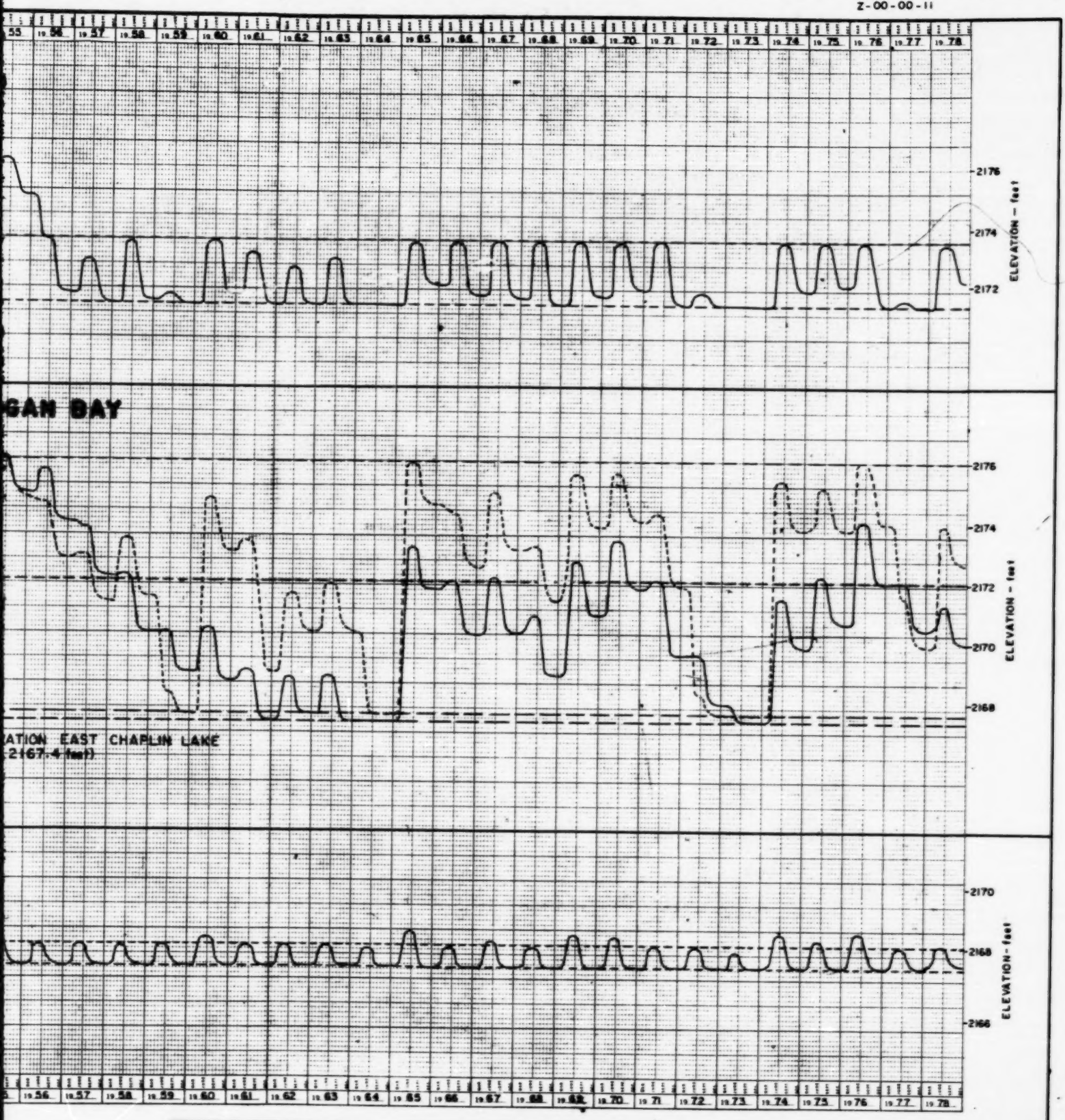

ELEVATION - metres
663.0
662.0
661.0
F.S.L. MIDTSKOGAN BAY 663.24 (2176.0 feet)
MIDTSKOGAN BAY
F.S.L. EAST CHAPLIN LAKE 662.03m (2172.0 feet)
EAST CHAPLIN LAKE
DRY ELEVATION MIDTSKOGAN BAY 660.68 m (2167.6 feet)
DRY ELEVATION EAST CHAPLIN LAKE 660.62 m (2167.4 feet)

WEST CHAPLIN LAKE



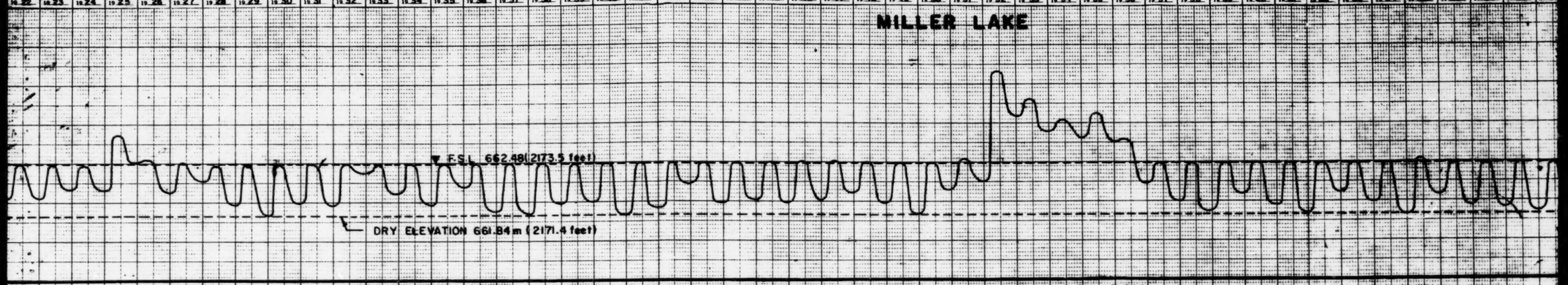
Saskatchewan Environment Hydrology Branch	
Drn.: G.V.J	Date: Jan. 29, 1981
Ck'd.	Plan No. H4-11 9)

Z-00-00-11

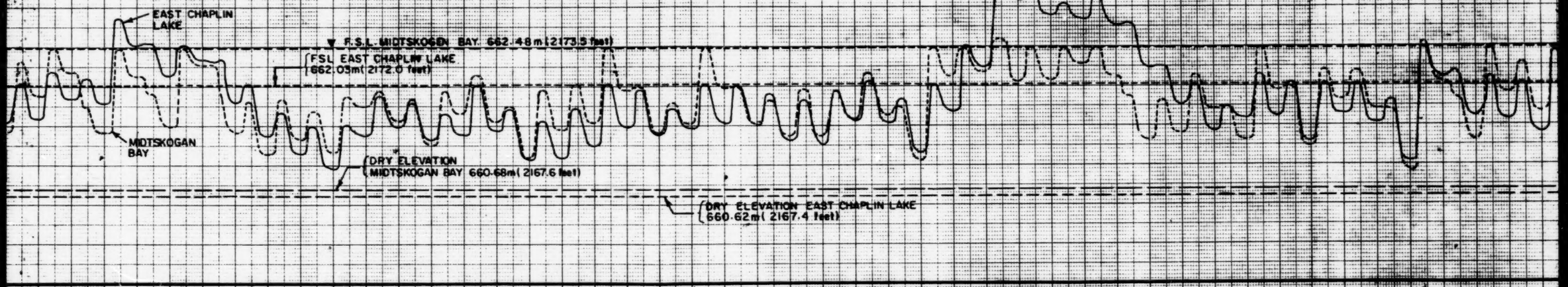


Saskatchewan Environment Hydrology Branch		CHAPLIN LAKE HYDROLOGY STUDY LAKE LEVELS UNDER CASE A2 OPERATION LOCAL RUNOFF ONLY	Figure 4
Drn.: G.V.J	Date: Jan. 29, 1981		
Ck'd.	Plan No. H4-1(9)		

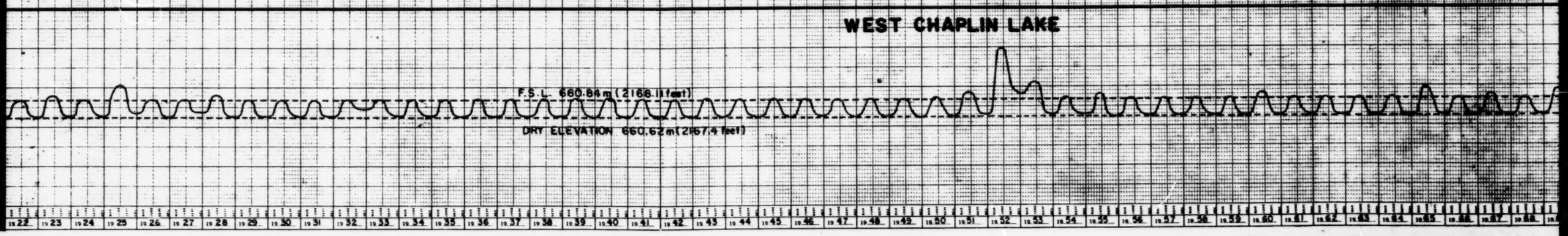
MILLER LAKE



EAST CHAPLIN LAKE & MIDTSKOGAN BAY

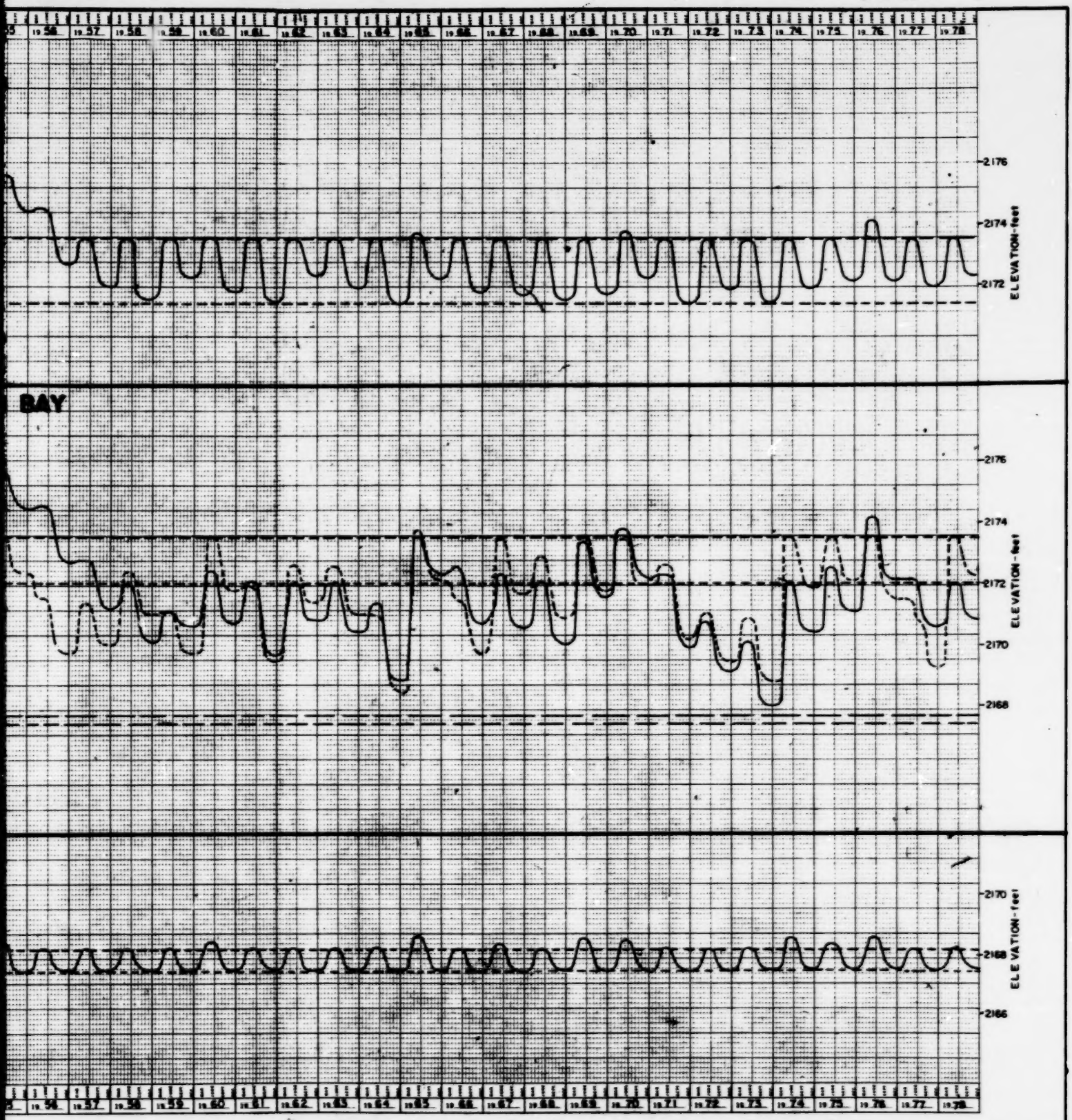

ELEVATION - metres
663.0
662.0
661.0
EAST CHAPLIN LAKE
F.S.L. MIDTSKOGAN BAY 662.48 m (2173.5 feet)
FSL EAST CHAPLIN LAKE 662.03m (2172.0 feet)
MIDTSKOGAN BAY
DRY ELEVATION MIDTSKOGAN BAY 660.68m (2167.6 feet)
DRY ELEVATION EAST CHAPLIN LAKE 660.62m (2167.4 feet)

WEST CHAPLIN LAKE



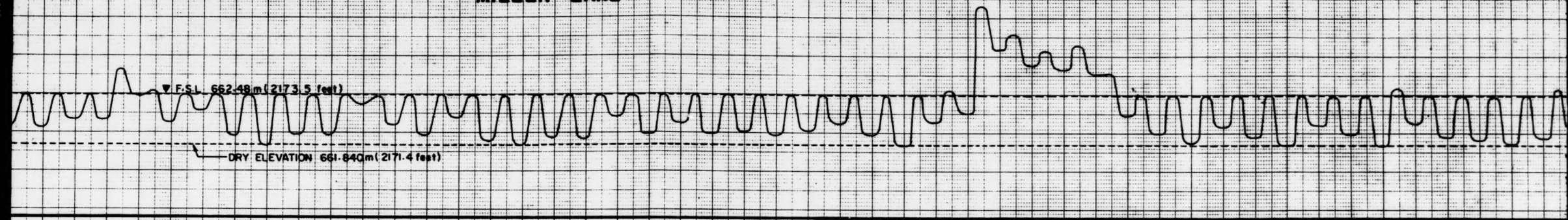
Saskatchewan Environment
Hydrology Branch

Drn.: G.V.J.	Date: Jan. 1981
Ck'd.	Plan No. H4-1( )

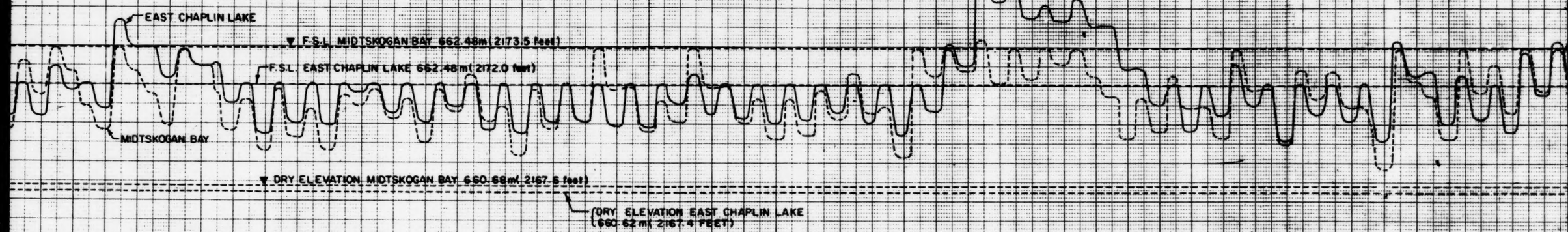


Saskatchewan Environment Hydrology Branch		CHAPLIN LAKE HYDROLOGY STUDY LAKE LEVELS UNDER CASE B4 OPERATION WATER IMPORTED UP TO GIVEN MAXIMUM	Figure
Drn.: G.V.J.	Date: Jan. 1981		5
Ck'd.	Plan No. H4-1(109)		

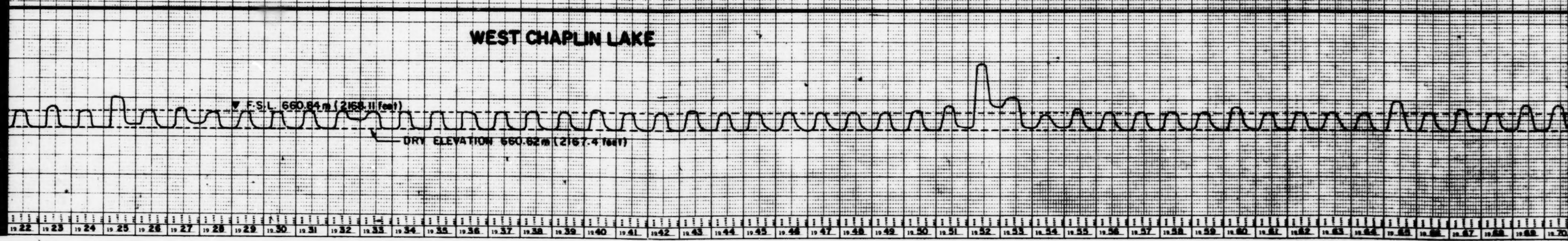
MILLER LAKE



EAST CHAPLIN LAKE AND MIDTSKOGAN BAY



WEST CHAPLIN LAKE



Saskatchewan Environment	
Hydrology Branch	
Drn.: G.V.J.	Date: Jan. 29, 1981
Ck'd.	Plan No. H4-1 (11)

Z-00-00-11

Saskatchewan Environment Hydrology Branch		CHAPLIN LAKE HYDROLOGY STUDY LAKE LEVELS UNDER CASE C5 OPERATION WATER IMPORTED AS REQUIRED	Figure 6
Drn.: G.V.J.	Date: Jan. 29, 1981		
Ck'd.	Plan No. H4-1 (11)		

POOR

QUALITY

ORIGINAL